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MULTI-LAYER PRINTING MODES

HP INC

Multi-Layer printing modes

Abstract

One of the applications of printers with white inks is to print on a transparent substrate and cover it with white, so that the image, printed in mirror image, is seen through the substrate on a white background. An unmirrored image can be printed on the other side, allowing for an image on both sides of the substrate. This is referred to as a (three-layer) *sandwich mode*.

To reduce translucency, a variation is the *five-layer sandwich mode*, in which the middle white layer is replaced by another sandwich of white, black and white.

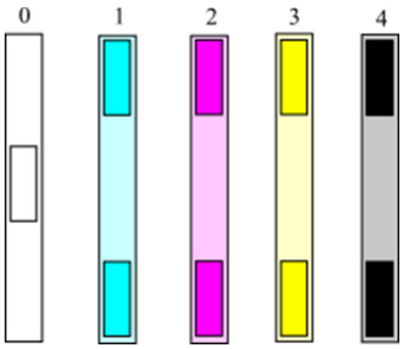
Depending on the hardware, in particular the carriage layout, this can be printed in a single job: so this has to print the first image in mirror image, then cover it with white, optionally a layer of black and another layer of white, and finally print the second image.

To do this, you need (logical) pens of all fluids needed for the first image at the bottom of your carriage, which passes over the image first, after that a pen with white ink, and finally another set of pens for the second image.

We describe an approach in which each physical trench (nozzle array) of a given colorant in a given pass only has to print the data of a single image plane, and mask it with a single mask. It is described how two image planes and two masks can be encoded in a single one, enabling the three layer mode with a single trench, and five layer with just two trenches, at the cost of a reduced bit depth of each image.

Three-layer mode

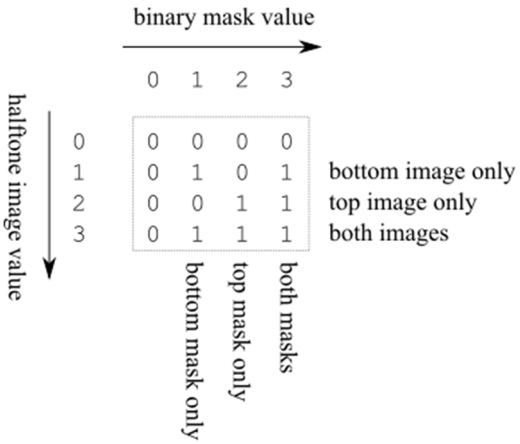
At an early stage in the process, possibly outside the printer, the content of both images and the blocking layer is produced and halftoned to (typically) 1 or 2 bits per colorant per pixel.



In this mode, here illustrated with an example of CMYK and white, one image is printed with the bottom part of the CMYK trenches, the opaque white layer is put in between, and the top image is printed with the top parts of the trenches.

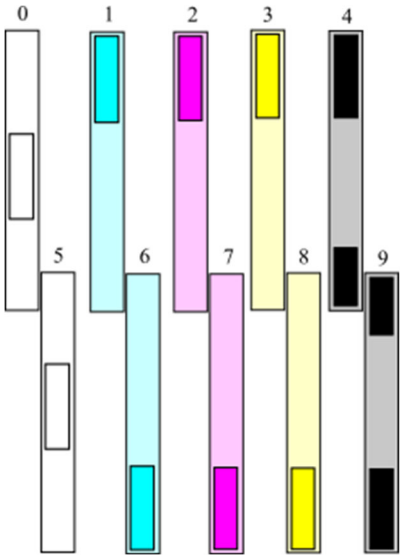
The top and bottom images can be encoded in a single image, one of them in the least significant bits, the other in the most significant bits, e.g. each plane of two 1-bit images encoded in a single 2-bit plane. To ensure the images are printed correctly, in each pass a mask of the size of the trench is used that contains a 1 at each position where a drop of the bottom image may be printed (depending on the image value), and a 2 where a drop of the top image may be printed.

Finally, in the printing process, the following lookup table (in the case of 1-bit images combined into a 2-bit image) is used to determine which combination of mask value and pixel value should result in a firing:



Five-layer mode

This is a variation of the preceding in which we have two trenches for each colorant, but we want to print five layers: an image on each side, and white-black-white in between.



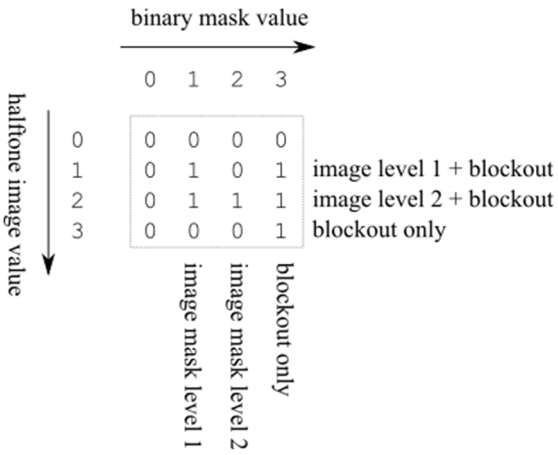
If it were not for the black blocking layer, nothing special would have to be done. One approach would be the same as in the three-layer mode, but an often, preferable alternative allows to increase the effective bit depth of the visible images, by restricting that of the blocking layer in an insignificant way.

In the case of having 2 bits for each colorant plane, if we demand that the blocking layer is such that it always prints where the corresponding layer of the visible has content (though it may also print where the other don't), then we can allow the visible images to have three different levels each (so not quite 4 levels, which can be encoded in 2 bits, but more than 2 levels that can be encoded in a single bit).

To that end we encode each image plane freely with the values 0,1,2, and we mix in values of 3 at positions where the blocking layer prints, but not the visible image.

Each of the trenches gets a mask, now encoding with 1,2 the positions where to fire when the visible image's pixel value is at least 1 resp. 2, and a 3 where the block out layer has to be printed where the pixel value is 1,2 or 3.

Translating the combination of pixel value and mask value using the following lookup table gives exactly the required behavior.



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